Quard®
ABRASION RESISTANT STEEL

Quend®
HIGH YIELD STRENGTH STEEL

TECHNICAL RECOMMENDATIONS

NLMK Clabecq

02/2014

GENERAL INTRODUCTION

Quard® *is the brand name of the product group of abrasion resistant steel plates produced by NLMK Clabecq, currently covering the hardness levels of 400, 450 and 500 Brinell.The aim is to expand the product group to include the additional level of 550 Brinell.*

Quend® *is the brand name of the product group of high yield strength structural steel plates produced by NLMK Clabecq, beginning with Quend 700, which has a minimum yield strength of 700 MPa, continues with Quend 900 and Quend 960 and will be followed by Quend 1100.*

Quard®

ABRASION RESISTANT STEEL

Quend®

HIGH YIELD STRENGTH STEEL

CUTTING

NLMK Clabecq

1. Introduction

*Cutting **Quard**® and **Quend**® can be performed by any of the conventional cutting methods, using both cold and thermal cutting.*

Cold cutting means cutting by shearing, sawing, abrasive grinding and abrasive water jet cutting. The thermal cutting methods referred to in this manual are oxygen fuel cutting, plasma cutting and cutting by laser.

Cutting Quard and Quend does not differ substantially from cutting conventional steel grades. When cutting thicker gauges, there are, however, some aspects that must be considered.

This manual will give you a better understanding of how Quard and Quend operate during thermal processing and how to avoid mistakes during various cutting operations.

2. Cracks in cut edges

If thermal cutting of Q&T steels of thicker gauges and / or in grades exhibiting a sufficiently high carbon equivalent, cracks may form and propagate from the cut edges. These cracks are caused by similar reasons as cold cracks when welding, being :

- **Hydrogen content in the steel ;**
- **Cut edge residual stresses ;**
- **A high carbon equivalent.**

Cut edge cracks in Q&T steels are a delayed cracking phenomena, which means cracks may first appear and only become visible days, or even weeks, after the cutting process.

Cut edge cracking can be avoided if the following aspects are carefully considered :

- **Cutting method ;**
- **Preheating requirement ;**
- **Cutting speed ;**
- **Slow cooling/post heating.**

During thermal cutting, the plate edge exposed will be subjected to a thermal cycle, from the melting point of the steel down to ambient temperature. This area, referred to as the heat-affected zone (HAZ), is very limited and extends just a few millimetres. The HAZ width all depends on the cutting method and thickness of the plate. Since the mechanical properties in the HAZ are affected by cutting, it is important to consider the consequences when selecting the cutting method and procedure to be used.

If applying any of the cold cutting methods, no heat-affected zone will be developed, while the mechanical properties of the edge will be unaffected.

3. Preheating

The best way to avoid problems with cut edge cracking is to preheat prior to cutting. Preheating is most commonly applied during oxygen fuel cutting, since this method creates the widest heat-affected zone. The need for preheating and to which temperature, depends on the steel grade and plate thickness. Table 1 shows the preheating requirement for Quard.

Table 1. Preheat recommendations when oxy-fuel cutting of Quard.

Steel grade	Plate Thickness, mm	Preheating temperature, °C
Quard 400	≥50	100-125
Quard 450	≥40	100-125
Quard 500	≥25	100-150

Remark: In the thickness range up to 50 mm, Quend does not need any preheating prior to thermal cutting.

When starting up the thermal cutting process, the temperature of the plate should have an ambient temperature of min. 0°C.

After cutting, let the cut parts slowly cool down to room temperature. Never accelerate the cooling of the parts. A slow cooling rate will reduce the risk of cut edge cracking.

4. Cutting speed

If, preheating can not be applied, another option to reduce the risk of cut edge cracking is available. By reducing the speed during oxygen fuel cutting, the heat generated during the cutting process will act as preheating to the adjacent steel ahead. This method is not as reliable as the preferred preheating method to prevent cut edge cracking. To further reduce the risk of cut edge cracking, preheating and slow speed cutting can be combined. The option of reducing the cutting speed should be applied from the same plate thickness preheating is recommended to be used ; see Table 1. The restricted speed to use equates to 50% of the speed normally* applied when cutting the actual plate thickness.

*By normal speed we refer to the speed recommended by the cutting equipment supplier, usually given by the burning torch used.

5. Hardness gradients in cut edge

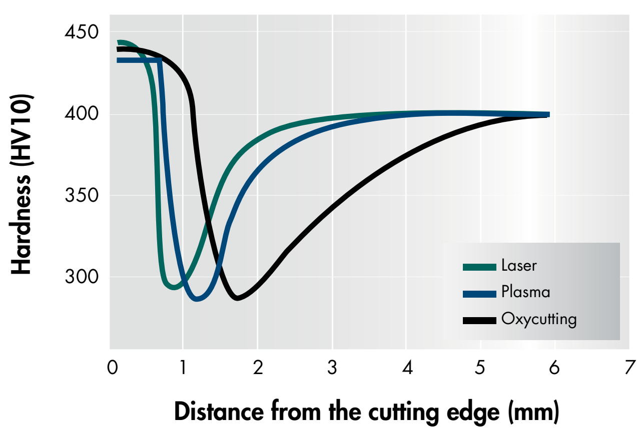
Depending on the cutting method used, the amount of heat added and accumulated in the plate differs. The more heat that is transferred to the plate, the larger the heat-affected zone. The widest heat affected-zone is generated by oxy-fuel cutting and the narrowest by laser cutting.

As for all thermal cutting methods, the hardness in cut displays a peak at the vicinity of the surface, followed by a hardness minimum at some 1-3 mm into the plate.

It is easy to understand that variation in hardness generates a certain stress condition in the HAZ that may encourage micro cracks to appear (especially if hydrogen is present).

Another effect from high peak cut edge hardness is found when performing milling operations of the cut edge.
To prevent extensive wear of the cutting tool, it is important that the feed rate during milling is set at a distance exceeding the depth of the hard surface layer.

Figure 1. HB vs. distance from edge surface / using different cutting methods.



6. Slow cooling and post heating

As mentioned earlier, slow cooling of thermally cut parts should always be applied.
To further slow down the cooling rate, it is recommended to stack the cut parts (still warm) together and cover the parts with insulating material.

If needed, post heating of the cut part can be performed. Post heating should be performed after finalising the cutting. The temperature used should be between 100 and 200°C and the time of heating should correspond to five minutes per mm plate thickness. The post heating is best performed in a heat treatment furnace but could also be done using oxy burners.

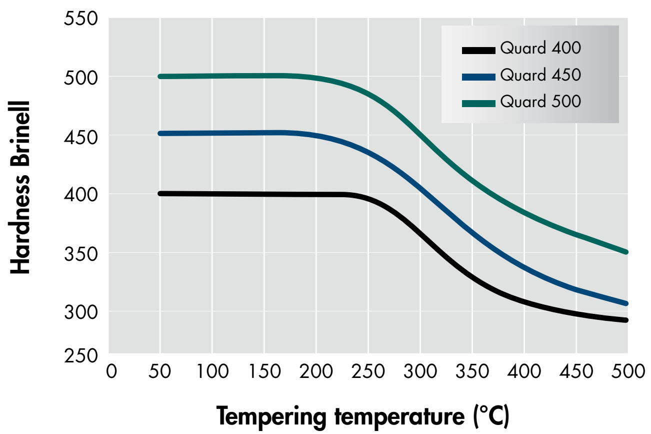
By applying slow cooling or post heating, the residual stresses in the cut will be reduced and, at the same time you extend the time for hydrogen to diffuse out of the cut area. These actions will further prevent cut edge cracking occurring.

7. Cutting small components of Quard

When cutting small-sized components, the heat generated during the cutting process will be accumulated in the component being cut. The smaller the part and / or the larger the plate thickness, the greater the risk of over tempering (softening) the part.

The temperature resistance of Quard is given in Figure 2, showing the hardness in relation to the tempering temperature.

Figure 2. Tempering resistance / Quard.



To preserve the hardness and thus the wear resistance when cutting small components, it is important to limit the heat accumulated in the cut part.

Minimising the accumulated heat when cutting small components can be achieved by:

- selecting the proper cutting method, such as laser cutting or abrasive water jet cutting, therefore minimising the heat generated;
- performing plasma or oxygen fuel cutting as submerged in water, using a water cutting table. In so doing, the water will effectively transfer the heat out of the plate.*

*Submerged cutting does not comply with what has been said about slow cooling. When cutting under water the heat-affected zone will be narrower than when cutting in air. Thus the harmful effect from the HAZ can be limited. When conducting submerged cutting the cutting speed is reduced by about 30 to 50% compared to normal cutting in air. This complies with the recommendation of applying slow cutting speeds for preventing cut edge cracking.

8. Laser cutting

Both **Quard** and **Quend** are suitable for laser cutting.

Quard and Quend can be delivered as primer coated or as quenched (black). Depending on the surface condition, the laser cutting performance may differ slightly between the two delivery conditions.

The primer used at NLMK Clabecq is of low zinc silicate type and is designed in such a way that limits the negative impact on the laser cutting performance, normally related to primer-coated plates.

When laser cutting on a primer-coated plate surface, targeting a high cut edge surface quality, the cutting speed may need to be reduced by 5 to 10% compared to laser cutting on a non-primer-coated plate.

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COLD FORMING

NLMK Clabecq

1. Introduction

Quard®*, abrasion resistant steel, and* ***Quend***®*, high yield strength steel, are designed for optimal cold forming performance. Requirements regarding steel cleanliness, consistent thickness properties, surface finish, low residual stresses and narrow thickness tolerances, promote an accurate, close and safe bending to be performed.*

In plate thickness from 8 mm and below, special attention has been paid to the design of Quard and Quend steel grades in order to reach outstanding bending performance.

The competitive strength of Quard and Quend, comprising of narrow thickness tolerances, excellent surface finish and flatness, promotes the cold forming capability of the steel.

Outstanding surface finish	**Increased crack integrity:** Reduces crack initiation points along the bend line
Narrow thickness tolerances	**Increased reproducibility:** Secures a constant spring back when bending
Flatness	**Increased reproducibility:** Improves shape tolerance when bending

2. Bending

Cold forming of plates involves plastic deformation, or stretching, of the plate surface on the outer tension side of the bend. The extent to which plastic deformation can occur, without exceeding the limits of the material ductility, controls the minimum radius of a bend which can be used for a specific operation.

The main factors determining the formability of steel, or the capacity to plastically deform without failure, have been listed under points A to E below:

A. The type of steel:

Low strength steel is generally more ductile than higher strength steel and is therefore capable of being bent to a narrower radius. In general, a low carbon content is a prerequisite for good formability, thus being able to use a lean composition to manufacture high-strength Q&T steel benefits the cold forming capability. The higher the steel strength and hardness the larger the spring back, the higher the punch force and the larger the tool radius required.

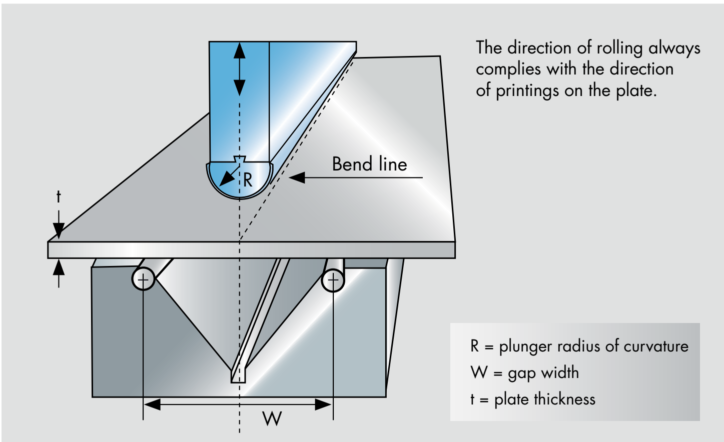
B. Direction of rolling:

Due to the rolling practice applied during the manufacturing process of steel plates, the plate properties will differ depending on the orientation relative to the rolling direction. In the transverse direction to rolling, the microstructure will be oriented in a more favourable way, thus the ductility, as well as the bending properties, are enhanced if the bending line is oriented transverse to rolling.

C. Condition of plate edge and surface:

Poor quality in the plate edges of the bending line or poor surface conditions along the bending line may act as crack initiation points, limiting the bending performance of the plate. For this reason, smoothening and / or removal of sharp corners / edges and slivers on sheared edges, gouge marks, dross formation on flame-cut edges, scratch marks and loose flaked mill scale along the bending line should be considered prior to bending. Always position the plate surface and / or edges of poorest quality on the inside / compressed side of the bend.

The bending machine.



D. Friction:

To lower the friction between the die edges and plate it is recommended to equip a die with freely-rotating steel rods. A further lowering of friction can be obtained by spraying lubricants in the contact zones between the die edges and plate.

The width of the die opening should be adapted to best suit the bending operation. By increasing the die opening width, the spring back will increase and the bending force will be reduced.

E. Punch tool:

When bending Q&T steels, the punch tool radius should have the same radius or somewhat larger radius than the targeted final radius of the plate being formed.

The radius of the tool should be chosen in such a way to accurately comply with the minimum R/t ratio given in the Quard and Quend bending recommendations in Tables 1 and 2.

To secure a proper plate to punch tool contact throughout the entire forming operation, the radius of the punch tool head should run 180°.

Caution

When cold forming high-strength Q&T steel, very high forces are in operation. With a risk of failure of either the plate or the press break, staff operating close to the machine must always follow the safety instructions, whereby they do not stand too close to, or in front of the machine, when bending.

3. Bending recommendations

A. Punch radius:

Minimum recommended punch radius, R (mm), when bending to an angle of 90° in the transverse and longitudinal direction to rolling.

Table 1. Quard abrasion resistant steel.

Plate Thickness, mm ≤ t <		Direction of bending vs. rolling	Bending radius, R (mm) Quard 400	Quard 450	Quard 500
-	8	Transverse Longitudinal	2.5 x t 3.0 x t	3.5 x t 4.0 x t	3.5 x t 4.5 x t
8	20	Transverse Longitudinal	3.0 x t 4.0 x t	4.0 x t 5.0 x t	4.5 x t 5.0 x t
20	-	Transverse Longitudinal	4.5 x t 5.0 x t	5.0 x t 6.0 x t	6.0 x t 7.0 x t

Table 2. Quend high yield strength steel.

Plate Thickness, mm ≤ t <		Direction of bending vs. rolling	Bending radius, R (mm) Quend 700	Quend 900 Quend 960
-	8	Transverse Longitudinal	1.5 x t 2.0 x t	2.5 x t 3.0 x t
8	20	Transverse Longitudinal	2.0 x t 3.0 x t	3.0 x t 4.0 x t
20	-	Transverse Longitudinal	3.0 x t 4.0 x t	4.0 x t 5.0 x t

B. Die opening:

The minimum recommended die opening (W/t - ratio), when bending Quard and Quend, should be taken according to the following tables.

Table 3. Quard abrasion resistant steel.

Plate Thickness, mm ≤	t <	Direction of bending vs. rolling	Die opening (W/t) Quard 400	Quard 450	Quard 500
-	8	Transverse Longitudinal	8 10	10 10	10 12
8	20	Transverse Longitudinal	10 10	10 12	12 14
20	-	Transverse Longitudinal	12 12	12 14	16 18

Table 4. Quend high yield strength steel.

Plate Thickness, mm ≤	t <	Direction of bending vs. rolling	Die opening (W/t) Quend 700	Quend 900 Quend 960
-	8	Transverse Longitudinal	8 9	9 10
8	20	Transverse Longitudinal	8 9	9 10
20	-	Transverse Longitudinal	9 10	10 12

C. Spring back:

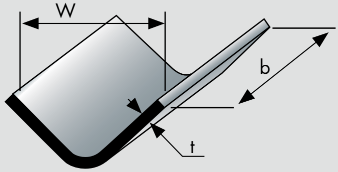
Estimated spring back when bending to 90°.	
Steel grade	**Typical spring back**
Quard 400	8-12°
Quard 450	10-14°
Quard 500	12-18°
Quend 700	6-10°
Quend 900 / 960	8-12°

The spring back increases with:

- **Increasing plate hardness and strength;**
- **Increasing width of die opening;**
- **Increasing punch tool radius.**

4. Calculation of bending force

Energy required for bending.



$$F = C \cdot \frac{R_m \cdot b \cdot t^2}{W}$$

R_m = tensile strength, (MPa)
t = plate thickness, (mm)
C = constant (1.5)
b = lenght to be bent, (mm)
W = width of the V groove, (mm)

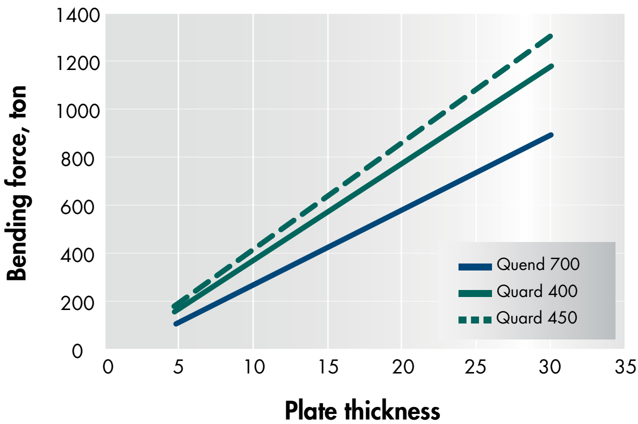
Example:
Quard 400:
R_m: 1,250 MPa;
plate thickness (t) = 10 mm;
bending length (b) = 2,500 mm;
Die width (W): 120 (W = 12 x t).

Calculation of bending force:

$$F \text{ (Newton)} = 1.5 \times \frac{(1{,}250 \times 2{,}500 \times 10^2)}{120}$$

F = 3906250 Newton / 10,000
= 391 ton, (see graph)

Bending force required when bending Quard 400, 450 and Quend 700 plates in lengths of 2,500 mm shown in plate thickness.



Quard®

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HIGH YIELD STRENGTH STEEL

WELDING

NLMK Clabecq

1. Introduction

Quard®*, abrasion resistant steel, and* ***Quend***®*, high yield strength structural steel, combine their outstanding performance with excellent weldability. Both Quard and Quend are based on a low-alloy steel composition securing carbon equivalents at low levels. Welding of Quard and Quend can be carried out with all weldable steel grades using any of the conventional welding methods, either manually or automatic.*

Welding Quard and Quend is as easy as welding commercial steel grades. However, to obtain high-quality welds when welding Quard and Quend, special attention must be paid to the following aspects:

- *Need for preheating prior to welding*
- *Weld heat input applied*
- *Selection of electrode.*

2. Preheating

When welding Q&T steels in thicker gauges, the preheating of the joint area prior to welding becomes necessary in order to prevent weld cracks occurring.

The need for preheating, and at what temperature, depends on several factors : 1) the steel carbon equivalent, 2) the stress conditions in the weld and 3) the type of electrode used.

The carbon equivalent is calculated based on the steel composition specified in the plate certificate. The carbon equivalent is normally given as either CEV or as CET. The CEV equivalent is the more traditionally and frequently used value for expressing the carbon equivalent of steel. The CET equivalent, on the other hand, is designed to better adapt to quenched and tempered steel grades. Both equivalents are given in all technical documentation on the weldability of Quard and Quend.

Irrespective of which carbon equivalent is used, the general rule is the higher the carbon equivalent, the more attention must be paid to preheating.

$$CEV(IIW) = C + Mn/6 + [Mo+Cr+V]/5 + [Ni+Cu]/15 \ (\%)$$

$$CET = C + [Mn+Mo]/10 + [Cr+Cu]/20 + Ni/40 \ (\%)$$

Note :
When comparing carbon equivalents between different steel grades, be sure you compare the same type of equivalent.
When calculating the carbon equivalent of a Quard or Quend plate, always use the ladle composition given in the product certificate, not the maximum analysis given in the data sheet.

3. Hydrogen cracking / Cold cracking

If preheating recommendations are not respected when welding **Quard** or **Quend** in thicker gauges, problems with weld cracking might occur. These types of cracks are referred to as hydrogen cracking or cold cracking, and will appear about 48 hours after welding is completed.

The issue with hydrogen cracking can be totally eliminated by carefully taking into account the preheating requirements of the steel, as well as the recommendations given on consumable selection.

Hydrogen cracks are mainly caused as a result of one or a combination of the factors given below.

- **The carbon equivalent being too high;**
- **The stress condition in the weld is too high;**
- **The hydrogen content in the weld metal deposit is too high.**

The primary purpose of preheating is to slow down the cooling rate in the heat-affected zone and weld metal so the hydrogen can slowly diffuse out of the steel. Preheating is most important when welding the root bead as well as when tack welding, since the plate is cold at the start of the welding process.

4. How to avoid hydrogen cracking

By choosing **Quard** and **Quend**, you have automatically selected steel grades produced according to a low-alloy concept, granting very low carbon equivalents regarding their hardness / strength and thus providing excellent weldability.

By obtaining a good fitting of the parts to be welded, and if a balanced welding sequence can be applied, stress built up during welding can be kept to a minimum. By following our instructions, you can select a suitable electrode which suits your requirements perfectly. In doing so, you will avoid unnecessary stresses being built up in the welded joint.

Except for selecting an electrode with the relevant strength, it is essential that the hydrogen content of the welded metal remains low. Always use electrodes that exhibit a weld metal hydrogen content of max. 5 ml / 100 g weld metal. The typical weld metal hydrogen content is always given on the packaging by the supplier.

To obtain a good weld quality when using Quard and Quend, it is recommended that the necessary welding hygiene standards be maintained, keeping the joints clear from rust, oil, grease and moisture.

5. Recommended preheating temperatures

The preheating requirement increases with:

- **Increasing carbon equivalent;**
- **Increasing plate thickness;**
- **Increasing hydrogen content in the as deposit weld metal;**
- **Decreasing heat input.**

The recommended minimum preheating requirement is given in relation to single plate thickness. The test method on which the preheating recommendations are based is the Tekken test.

Table 1. Welding with a heat input of ≥ 1.7 kJ / mm. As deposit weld metal hydrogen content: ≤ 5 ml / 100 g weld metal.

	Single plate thickness, mm: 3–10	10–15	15–20	20–30	30–40	40–50
Quard 400				75		100*
Quard 450				125		150*
Quard 500		100	125	150*	175*	200*
Quend 700					100*	
Quend 900/960		100	125*			

*Preliminary calculated preheat temperatures. Products under development in 2014.

IMPORTANT NOTE!!!

- **If preheating is to be applied, preheating must also be performed during the initial tack welding and fitting / clamping of plates.**
- **When performing tack welding, the length of the welds should be at least 50 mm.**
- **If the carbon equivalent of the consumable is higher than the carbon equivalent of the plate, a preheating temperature approximately 25°C higher than the temperature given in Tables 1 and 2 must be applied.**
- **If preheating is to be applied, the temperature in the weld must not fall below the preheating temperature specified during the entire welding sequence.**
- **If the ambient temperature or the temperature of the plate when welding remains below +5°C, the recommended preheating temperature should be increased by 25°C.**

6. Recommended interpass temperature

In multiple bead welds and short sequence weld lengths, the heat generated from the beads will be accumulated and increase the temperature in the welded area. As a result, the temperature in the weld before applying the next bead may become very high. In order to avoid a too high interpass temperature, which could affect the mechanical properties in the heat-affected zone, the recommended maximum interpass temperatures, given in Table 2, must be respected.

Table 2. Recommended maximum interpass temperature.

Grade	Interpass temp.
Quard 400 / 450	225°C
Quend 700 / 900 / 960	325°C

7. Recommended heat input

The heat input expresses the energy (heat) that is put into the weld during the welding of one weld bead.

The higher the heat input, the more heat needs to be transferred from the weld into the steel.

Calculation of welding heat input.

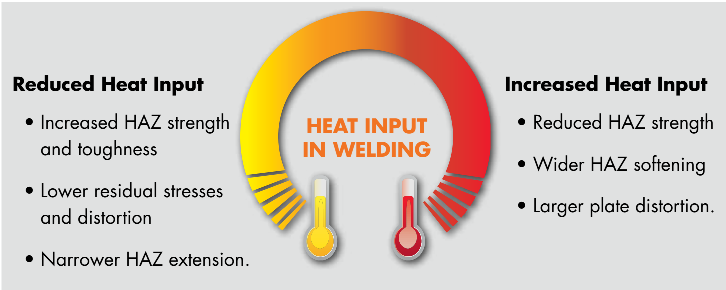
$$Q = \frac{k \times U \times I \times 60}{v \times 1000}$$

Q = Heat input (KJ / mm)
U = Voltage (V)
I = Current (A)
v = Welding speed (mm / min.)
k = Thermal efficiency

Thermal efficiency	k
MMA	0,8
MAG, all types	0,8
SAW	1,0
TIG	0,6

Quard and Quend receive their mechanical properties by quenching and, when necessary, by subsequent tempering. If the heat-affected zone (HAZ) is being exposed to very high temperatures, the mechanical properties upon delivery might be affected.

Effect on heat input on the weld mechanical properties.



A high heat input promotes high productivity. However, if it is too high, it will have a negative impact on the weld strength, impact toughness, weld distortion and extension of the heat-affected zone.

The total heat exposure of the HAZ is controlled by the combination of heat input and the preheating / interpass temperature. Restrictions regarding the maximum heat input have been suggested (Figures 1 and 2) in order to avoid jeopardising the properties of the heat-affected zone.

Figure 1. Recommended max. / min. heat input when welding Quard 400 / 450.
(Minimum value refers to conventional welding methods).

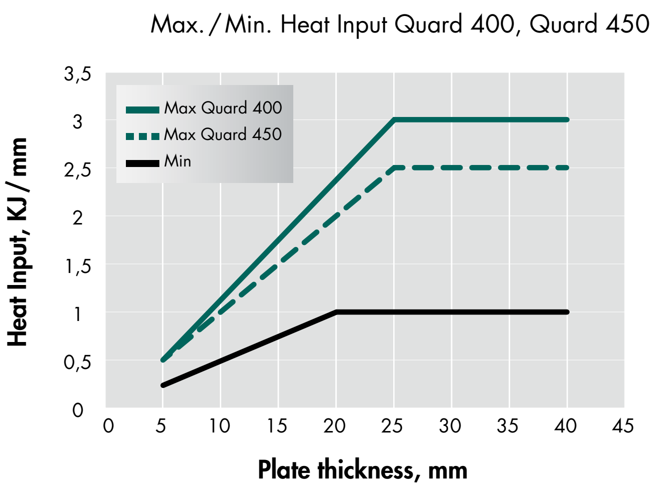
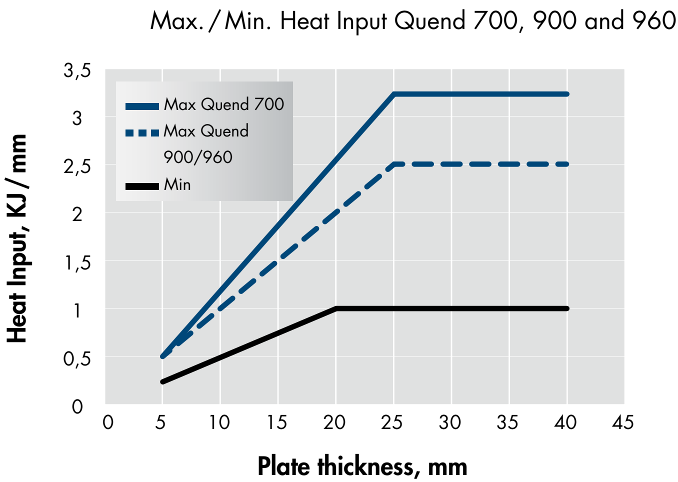


Figure 2. Recommended max. / min. heat input when welding Quend 700 / 900 / 960.
(Minimum value refers to conventional welding methods).



Recommended Δt8 / 5

Steel grade	Cooling time, 800°C to 500°C
Quend 700	5-25 s.
Quend 900 / 960	5-15 s.

8. Selection of electrodes

The electrodes recommended to be used when welding **Quard** and **Quend** are referred to the group of unalloyed or low-alloyed ferritic consumables. Depending on the welding method to be used, the electrode may be of solid wire type (GMAW) or in combination with a flux (as for MMA, SAW or FCAW welding). If using a flux system, it is recommended using a basic flux. This is because a basic flux generally produces a cleaner weld deposit and higher weld metal impact toughness, as well as being less susceptible to hydrogen pick up.

To minimise the risk of developing hydrogen cracks, welding should always be performed using low hydrogen electrodes, having an as deposit weld metal hydrogen content of max. 5 ml / 100 g weld metal.

When welding Quard abrasion resistant steels, electrodes having a yield strength of maximum 500 MPa should be used. Using higher strength electrodes increases the stress level in the weld and, in turn, the sensitivity to form cold cracks. By using an electrode of limited strength, the weld metal is allowed to relax stresses if exposed to high weld restrained conditions.

When welding Quend structural steels, the requirements of the applicable construction standard must be met regarding the transverse weld strength. In this case, consumables of matching or slightly overmatching yield strength must be selected. This means the weld metal strength should be the same or slightly higher than the strength of the parent metal. To find such electrodes is easy for Quend 700, yet for Quend 960-1100, only a few electrode manufacturers are able to supply these high-strength consumables.

In Tables 3-5, electrodes recommended to be used for welding Quard and Quend have been listed according to the weld method chosen. The AWS Class and EN Class designations have also been provided in the tables, representing the strength level, toughness and composition of recommended consumables.

Designation of weld methods:	
MMA	Manual Metal Arc welding
MAG / GMAW	Metal Active Gas welding – Gas Metal Arc Welding
MIG	Metal Inert Gas welding
FCAW	Flux Cord Arc welding
SAW	Submerge Arc Welding

Table 3. Ferritic consumables suitable for welding of Quard 400 / 450 / 500.

	MMA Manual metal arc	**GMAW** Gas metal arc	**FCAW** Flux corded arc	**SAW** Submerged arc
EN Class	EN ISO 2560 E4X	EN 440 G4X	EN 758 T4X	EN 756 S4X
AWS Class	A5.5 E70	A5.28 ER70S	A5.29 E7XT	A5.23 F7
ESAB	OK 48.00	OK Autrod 12.51	OK Tubrod 14.11	12.22 + 10.71
Oerlikon	Tenacito 70	Carbofil 1 (a)	Fluxofil 31/41	L-70 / OP121TT
Bohler	FOX EV47, EV48	EMK& , NiCu-1G	Kb 52-FD	EMS2 / BB22

Table 4. Ferritic consumables suitable for welding of Quend 700.

	MMA Manual metal arc	**GMAW** Gas metal arc	**FCAW** Flux corded arc	**SAW** Submerged arc
EN Class	EN 757 E69	EN 12534 G69	EN ISO 18276 T69	EN 14295 S69
AWS Class	A5.5 E110	A5.28 ER110-S	A5.29 E11XT	A5.23 F11
ESAB	OK 75.75	OK Autrod 13.29	OK Tubrod 14.03	13.43 + 10.62
Oerlikon	Tenacito 100	Carbofil NiMoCr	Fluxofil 42	–
Bohler	FOX EV85	Union NiCrMo	Union MV NiMoCr	–

Table 5. Ferritic consumables suitable for welding of Quend 900 / 960.

	MMA Manual metal arc	**GMAW** Gas metal arc	**FCAW** Flux corded arc	**SAW** Submerged arc
EN Class	EN 757 E89	EN 12534 G 89	EN ISO 18276 T89	EN 14295 S89
AWS Class	N/A	N/A	N/A	N/A
ESAB	OK 75.78	–	Coreweld 89	–
Bohler	–	Union X90 / X96	–	–

When selecting electrodes for welding Quend 900 and Quend 960, please consult Technical Support at NLMK Clabecq.

9. Austenitic consumables

Austenitic (stainless steel) consumables may be used for welding both Quard and Quend. The major benefit of using austenitic electrodes is that you can weld Quard and Quend of thicker gauges, where preheating is normally required, without preheating. The austenitic electrodes are far more expensive when compared to ferritic electrodes; however, if preheating is not possible, austenitic consumables become an option. The austenitic electrodes recommended for welding Quard should comply with the AWS 307 (or 309) classification, given in Table 6 below.

Table 6. Austenitic consumables suitable for welding of Quard 400 / 450 / 500.

	MMA Manual metal arc	**GMAW** Gas metal arc	**FCAW** Flux corded arc	**SAW** Submerged arc
EN Class	EN 1600 E18 8	EN 12072 G18 8	EN I2073 T18 8	EN 12072 S18 8
AWS Class	A5.4 E307	A5.9 ER307	A5.9 EC307	A5.9 ER307
ESAB	OK 16.45	OK Autrod 16.95	OK Tubrod 14.71	16.97 + 10.93

10. Improved wear resistance in welds

When welding Quard abrasion resistant plates, the weld should be positioned in low stressed areas and areas exposed to low wear from sliding or impacting abrasives. If the weld is located in areas exposed to high wear, the abrasion resistance of the weld can be improved by using hard-facing consumables when producing the top / cap beads of the weld. The hard-facing electrodes are usually very rich in chromium (3-13% Cr) ; this is why the carbon equivalent of the weld metal always exceeds the equivalent of the parent material. It is therefore important that the recommendations given by the hard-facing electrode supplier are followed, using the correct preheat and welding parameters.

11. Laser welding of Quard and Quend

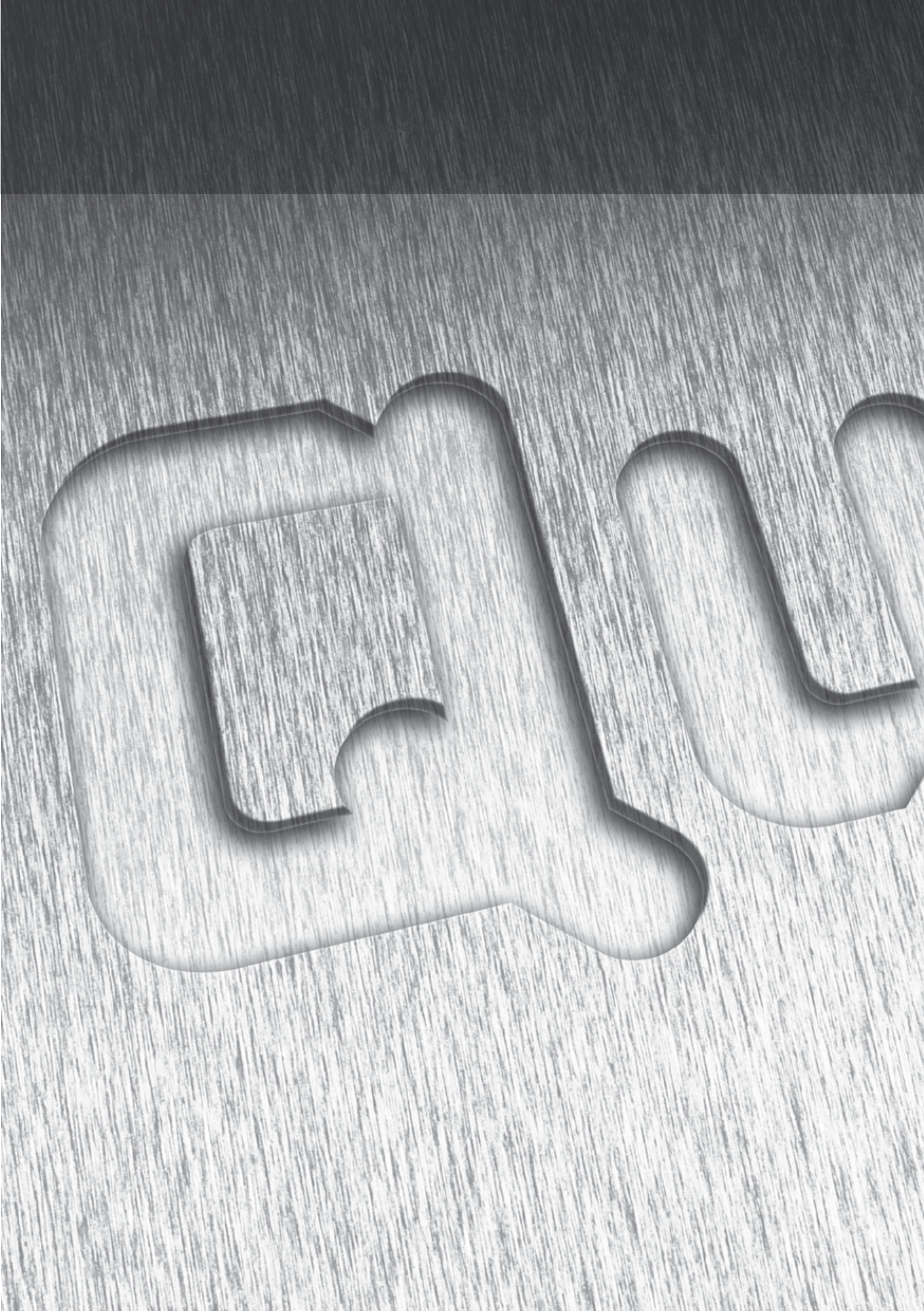
Laser welding can be used when welding Quard and Quend, with or without adding consumables. To secure the strength and toughness in the weld it is recommended to use laser welding together with a consumable. A proven welding process to obtain excellent weld mechanical properties is that of laser hybrid welding. For more information regarding laser welding of Quard and Quend, please contact our weld specialists at NLMK Clabecq Technical Support.

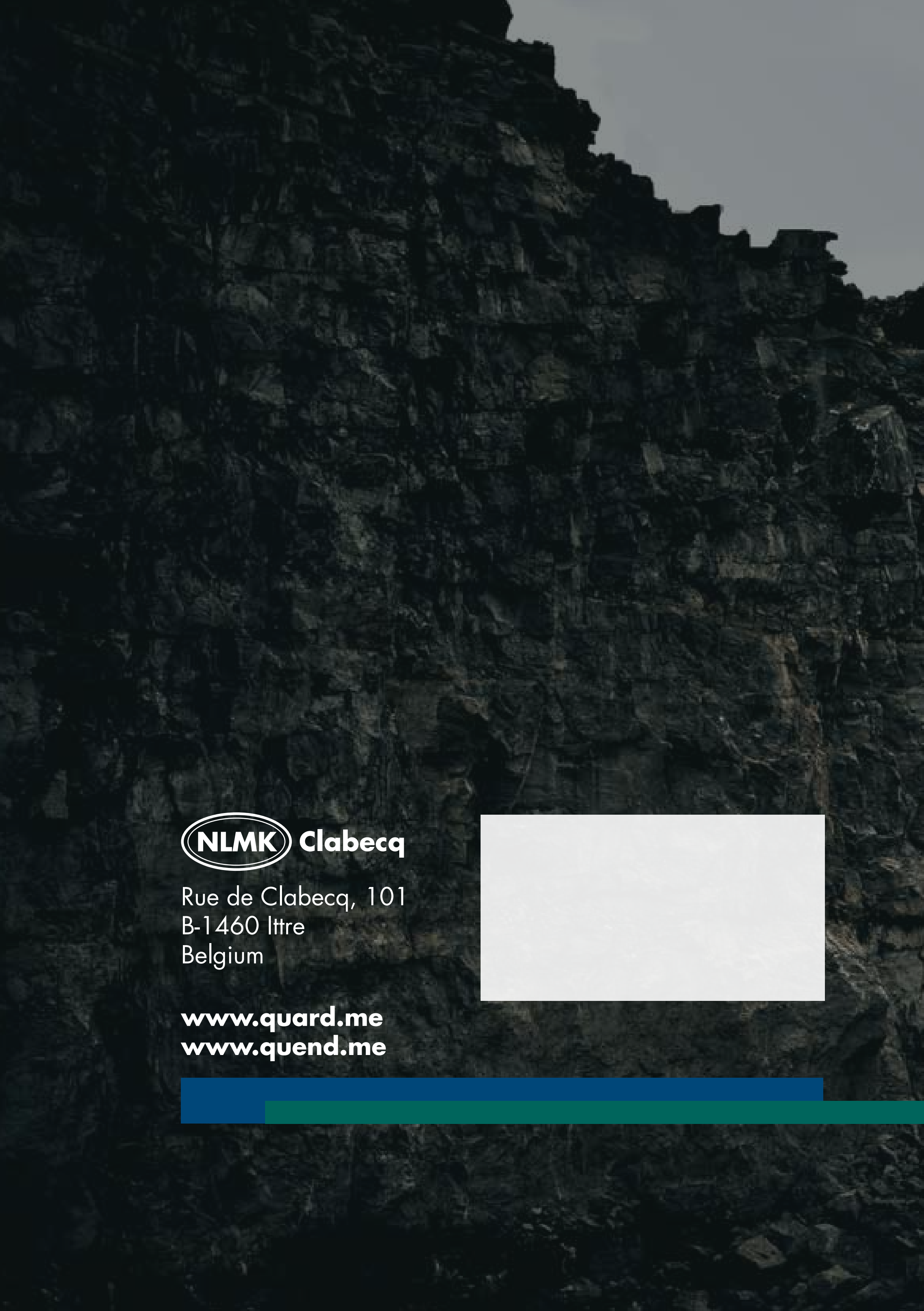
NOTES:

NOTES:

Quard®
ABRASION RESISTANT STEEL
Quend®
HIGH YIELD STRENGTH STEEL

NOTES:





NLMK Clabecq

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www.quend.me